Welcome to Psy 652 Lab!
Module 4:
Statistical Power

Objectives

- Explain statistical power
- Learn to calculate sample sizes from power & effect sizes via:
  - Murphy, Myors & Wolach (2014) Appendix E
  - G*Power

We will NOT be using R today!

(But you <u>can</u> do power calculations in R using the “pwr” package)

What is statistical power?

- **Power** = The probability of finding an effect (Assuming there is an effect) from our sample.
  - So, a power of .80 means that we have an 80% chance of detecting the effect in our sample *given the effect is there.*
  - In general, we desire to have a power level of .80 or better. Anything under .80 is generally considered insufficiently powered.

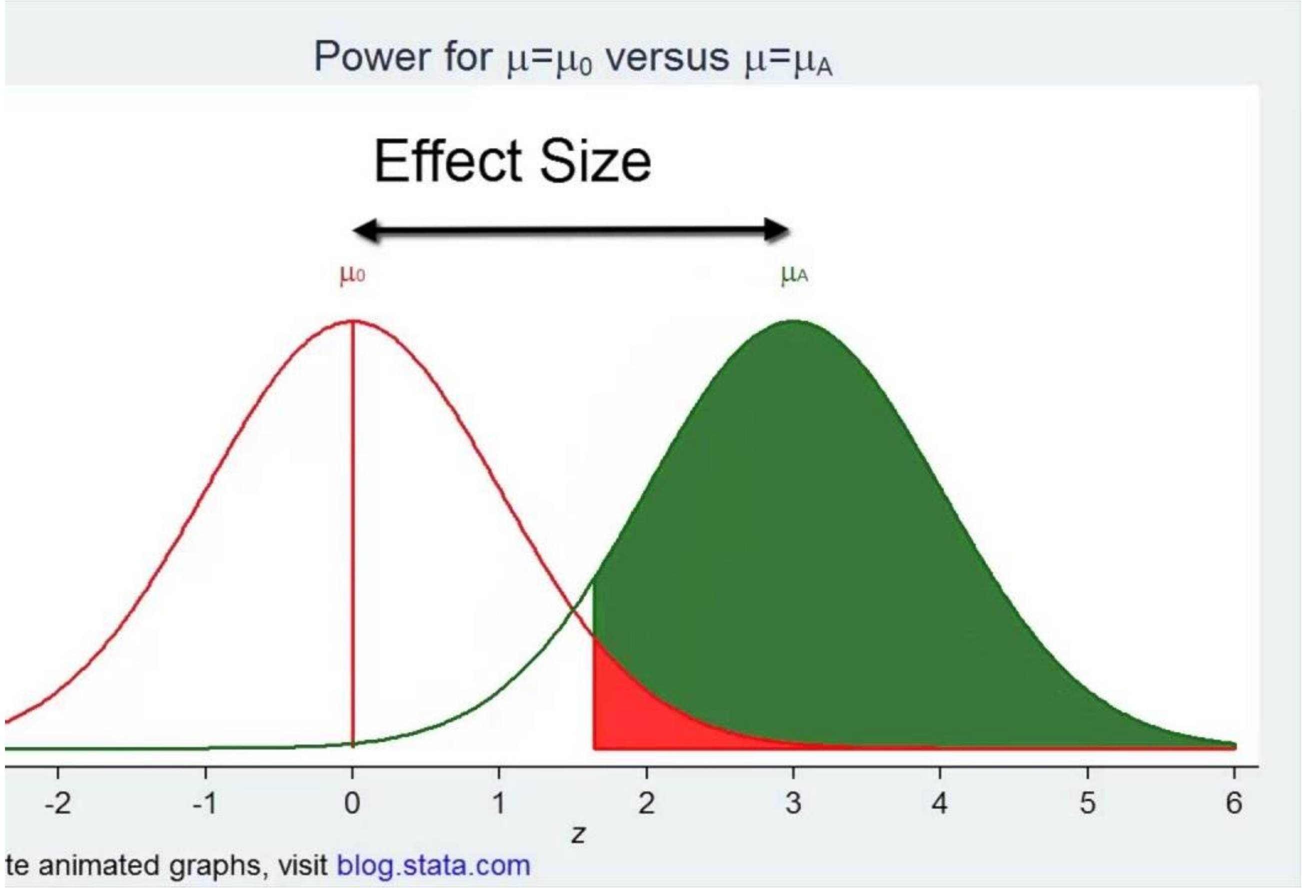
- We often use power a-priori to determine what a sufficient sample size will be. **If you are applying for a grant, you will likely need a power analysis!**

  - To determine **sample size**, we need 3 things:
    1. An **alpha value (α)** – The probability of getting a type I error (Usually set $\alpha = .05$ in psychology)
    2. An **effect size** (Determined through the literature – Meta analyses!)
    3. A desired **power (1 - β) level** (Usually set to .80)

What is an effect size?

- Effect size = The ***standardized*** difference between your groups or the proportion of variance explained.

- There are many type of effect sizes (Cohen's-d, PV, Odds ratios, R^2 etc.)
    - In this lesson, we will use PV and Cohen's-d



Effect size, α, sample size, study complexity, and power: A relationship

- As effect size increases, so does power
- As α increases, so does power
  - Consequence: You increase the chance of making a type I error
    - A type I error is the chance to say an effect exists, when it does not exist
- As sample size increases, so does power
- As study complexity increases, power decreases
  - For example: All else equal, a study with 4 comparison groups will have less power than a study with 3 comparison groups

Today we will be covering two methods to calculate sample sizes

1. Murphy, Myors & Wolach (2014) Appendix E (Available in Canvas)
2. G*Power (A downloadable power calculator program for Mac & Windows)
   - https://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower.html

Appendix E - The *df*Err Needed for *Power* = .80 (*Alpha* = 0.05) in Tests of Traditional Null Hypothesis

		*df*Hyp																
PV	*d*	1	2	3	4	5	6	7	8	9	10	12	15	20	30	40	60	120
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.02	0.29	385	473	533	579	627	662	694	722	762	787	832	909	993	1176	1313	1413	2010
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.04	0.41	190	233	263	286	310	328	343	358	377	390	413	451	494	585	654	774	1031
.05	0.46	151	186	209	228	247	261	273	285	300	310	329	359	402	466	522	618	825
.06	0.51	125	154	173	189	204	216	227	236	249	257	273	298	333	388	434	514	687
.07	0.55	106	131	148	161	174	184	193	204	212	220	233	255	285	331	371	440	601
.08	0.59	92	114	128	140	152	160	168	178	185	191	203	222	248	289	324	384	525
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.12	0.74	60	74	83	92	99	104	110	116	121	125	135	145	163	190	218	259	355
.13	0.77	55	68	76	84	90	96	101	106	111	115	124	133	150	178	200	238	327
.14	0.81	50	62	70	78	83	88	94	98	102	106	114	123	138	165	185	220	302
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.16	0.87	43	54	61	67	72	76	81	85	88	92	99	107	120	143	161	192	268
.17	0.91	40	50	57	63	68	72	76	80	83	86	93	101	112	134	151	183	251
.18	0.94	38	47	53	59	63	67	71	75	78	81	87	96	106	126	142	172	236
.19	0.97	36	44	50	55	59	63	67	70	73	77	82	90	101	119	136	163	227
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.24	1.12	27	34	39	42	46	49	52	54	57	59	63	69	78	93	105	128	178
.26	1.19	25	31	35	38	42	44	47	49	52	54	58	63	71	85	96	117	163
.28	1.25	22	28	32	35	38	41	43	45	48	49	53	58	65	78	90	107	152
.30	1.31	21	26	30	32	35	37	40	42	44	45	49	53	61	72	83	100	142
.32	1.37	19	24	27	30	33	35	37	39	40	42	45	50	56	68	76	93	131
.34	1.44	18	22	25	28	30	32	34	36	38	39	42	46	52	63	72	87	123
.36	1.50	16	20	23	26	28	30	32	33	35	37	39	43	49	59	67	81	115
.38	1.57	15	19	22	24	26	28	30	31	33	34	37	40	45	55	62	76	108
.40	1.63	14	18	20	23	24	26	28	29	31	32	35	38	43	52	59	72	101
.42	1.70	13	17	19	20	23	24	26	27	29	30	32	36	40	48	55	67	96
.44	1.77	12	15	18	20	21	23	24	26	27	28	30	33	38	45	52	64	91

Method 1: Murphy, Myors & Wolach (2014) **Appendix E**

Appendix E - The *df*Err Needed for *Power* = .80 (*Alpha* = 0.05) in Tests of Traditional Null Hypothesis

PV	*d*	1	2	3	4	5	6	7	8	9	10	12	15	20	30	40	60	120
		*df*Hyp																
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.03	0.35	255	313	353	384	416	439	460	479	505	[illegible]	552	603	660	782	874	1008	1341
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.05	0.46	151	186	209	228	247	261	273	285	300	310	[illegible]	359	402	466	522	618	825
.06	0.51	125	154	173	189	204	216	227	236	249	257	[illegible]	298	333	388	434	514	687
.07	0.55	106	131	148	161	174	184	193	204	212	220	[illegible]	255	285	331	371	440	601
.08	0.59	92	114	128	140	152	160	168	178	185	191	203	222	248	289	324	384	525
.09	0.60	81	100	113	124	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.10	0.67	73	90	101	110	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.11	0.70	66	81	91	101	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.12	0.74	60	74	83	92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.13	0.77	55	68	76	84	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.14	0.81	50	62	70	78	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.15	0.84	47	58	65	72	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.16	0.87	43	54	61	67	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.17	0.91	40	50	57	63	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.18	0.94	38	47	53	59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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.44	1.77	12	15	18	20	21	23	24	26	27	28	30	33	38	45	52	64	91

This table assumes you set an alpha value at .05 & a Power of .80

Method 1: Murphy, Myors & Wolach (2014) Appendix E

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.42	1.70	13	17	19	20	23	24	26	27	29	30	32	36	40	48	55	67	96
.44	1.77	12	15	18	20	21	23	24	26	27	28	30	33	38	45	52	64	91

Red = df_{Hyp}

Orange = Effect size (d or PV)

Green = df_{Err}

*Terms defined on next slide

Term definitions

- **df_{hyp}**: Is an index of the complexity of the problem. For example, when comparing the 2 groups, $df_{hyp} = 1$. When comparing 5 groups, $df_{hyp} = 4$. If you are evaluating 7 predictors of an outcome, your $df_{hyp} = 6$.
- **Effect size**: The proportion of variance explained (PV of .20 = 20% of the variance explained) or the standardized difference between groups (d of .20 = there are .20 standard deviations between the groups).
- **df_{err}**: The degrees of freedom for the estimate of error used in the test.
- **Sample size**: **N** = **df_{hyp}** + **df_{err}** + 1

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- **Sample size**: $N = df_{hyp} + df_{err} + 1$

THE END PRODUCT!

How to use Appendix E to get sample size

1. Identify your **df_{Hyp}**
   - The number or groups (or predictors) minus 1 (groups – 1)
2. Determine your **effect size**
   - Normally found in the literature via meta analyses
3. Determine the **df_{Err}** using your **df_{Hyp}** and **effect size**
4. Calculate the **sample size**
   - **N** = **df_{hyp}** + **df_{err}** + 1

An example

- You are conducting a study that has 2 groups in it (an experimental and control group). A meta analytic review has recently shown that the effect size is shown to be PV = .10. How many participants are needed to reach a desired power of .80 with an alpha of .05?

An example

- You are conducting a study that has **2 groups** in it (an experimental and control group). A meta analytic review has recently shown that the effect size is shown to be **PV = .10**. How many participants are needed to reach a desired power of .80 with an alpha of .05?

- df_{Hyp} = Groups -1 = 2 - 1 = **1**
- PV = **.10**
- **Next step:** Find the $\mathbf{df_{Err}}$

Finding the df_{Err}

Appendix E – The *df*Err Needed for *Power* = .80 (*Alpha* = 0.05) in Tests of Traditional Null Hypothesis

		*df*Hyp																
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.40	1.63	14	18	20	23	24	26	28	29	31	32	35	38	43	52	59	72	101
.42	1.70	13	17	19	20	23	24	26	27	29	30	32	36	40	48	55	67	96
.44	1.77	12	15	18	20	21	23	24	26	27	28	30	33	38	45	52	64	91

- $df_{Err} = 73$
- Sample Size: $df_{hyp} + df_{Err} + 1$
- 1 + 73 + 1 = **75**
- We need **75** participants to reach a power of .80

Another example

- You are running an observational study, For your analyses, you plan to use 7 variables to predict one outcome. Your advisor tell you the general effect size for the predictor of interest and outcome is PV = .23. How many participants are needed to reach a power of .80 with an alpha of .05?

Another example

- You are running an observational study, For your analyses, you plan to you plan to use **7 variables** to predict one outcome. Your advisor tell you the general effect size for the predictor of interest and outcome is **PV = .23**. How many participants are needed to reach a power of .80 with an alpha of .05?

- df_{Hyp} = predictors -1 = 7 - 1 = **6**
- PV = **.23**
- **Next step:** Find the $\mathbf{df_{Err}}$

Finding the df_{Err}

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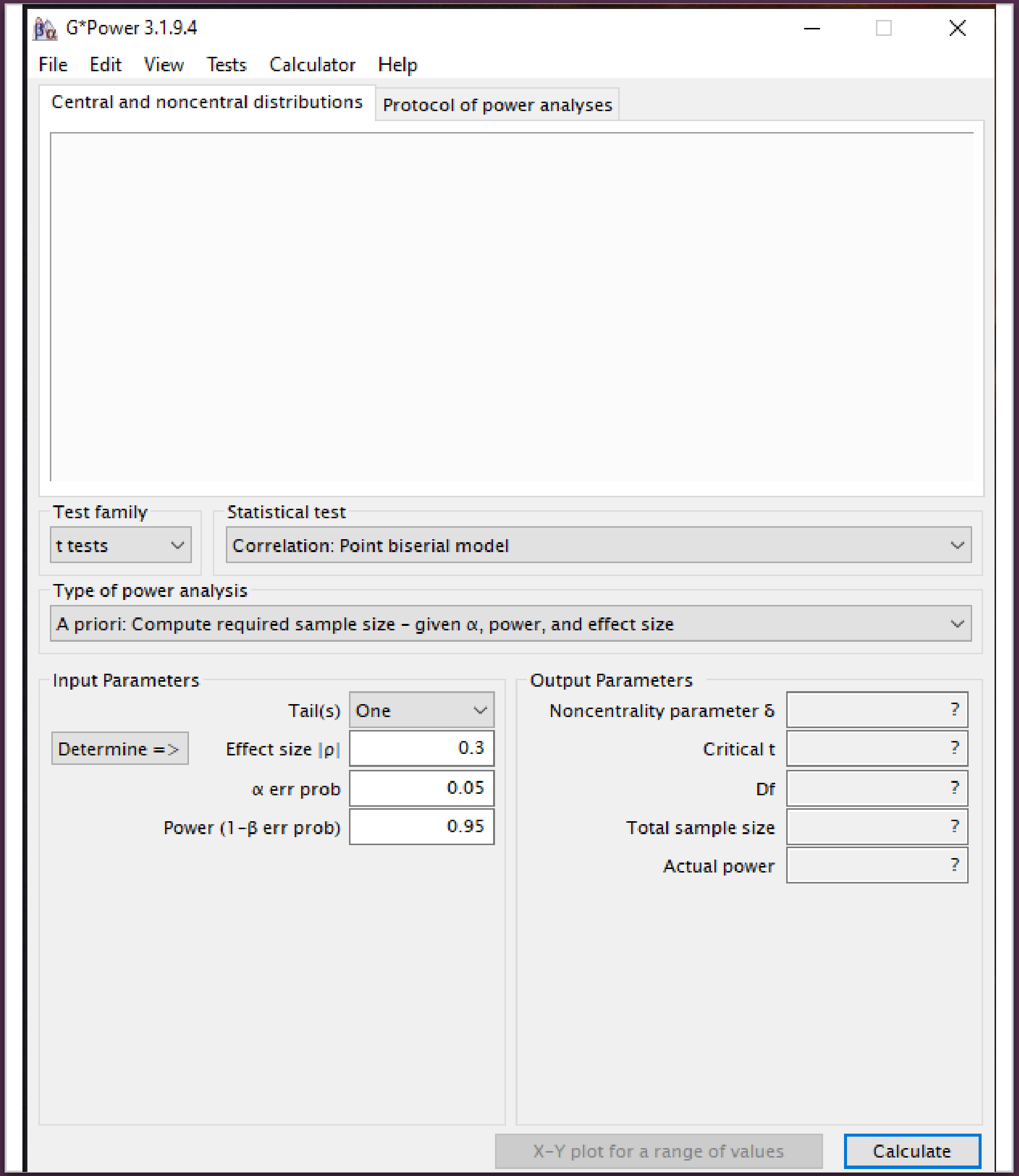
		*df*Hyp																
PV	*d*	1	2	3	4	5	6	7	8	9	10	12	15	20	30	40	60	120
.01	0.20	775	952	1072	1165	1260	1331	1394	1451	1504	1580	1670	1825	1992	2302	2565	3027	4016
.02	0.29	385	473	533	579	627	662	694	722	762	787	832	909	993	1176	1313	1413	2010
.03	0.35	255	313	353	384	416	439	460	479	505	522	552	603	660	782	874	1008	1341
.04	0.41	190	233	263	286	310	328	343	358	377	390	413	451	494	585	654	774	1031
.05	0.46	151	186	209	228	247	261	273	285	300	310	329	359	402	466	522	618	825
.06	0.51	125	154	173	189	204	216	227	236	249	257	273	298	333	388	434	514	687
.07	0.55	106	131	148	161	174	184	193	204	212	220	233	255	285	331	371	440	601
.08	0.59	92	114	128	140	152	160	168	178	185	191	203	222	248	289	324	384	525
.09	0.60	81	100	113	124	134	142	149	157	164	169	179	196	220	256	287	341	466
.10	0.67	73	90	101	110	120	127	133	141	146	152	161	176	197	230	258	312	419
.11	0.70	66	81	91	101	108	115	120	127	132	137	148	159	178	208	238	283	388
.12	0.74	60	74	83	92	99	104	110	116	121	125	135	145	163	190	218	259	355
.13	0.77	55	68	76	84	90	96	101	106	111	115	124	133	150	178	200	238	327
.14	0.81	50	62	70	78	83	88	94	98	102	106	114	123	138	165	185	220	302
.15	0.84	47	58	65	72	77	82	87	91	95	98	106	115	129	153	172	205	286
.16	0.87	43	54	61	67	72	76	81	85	88	92	99	107	120	143	161	192	268
.17	0.91	40	50	57	63	68	72	76	80	83	86	93	101	112	134	151	183	251
.18	0.94	38	47	53	59	63	67	71	75	78	81	87	96	106	126	142	172	236
.19	0.97	36	44	50	55	59	63	67	70	73	77	82	90	101	119	136	163	227
.20	1.00	34	42	47	52	56	60	64	67	69	73	77	85	96	112	129	154	214
.22	1.06	30	37	42	47	51	54	57	60	62	65	70	76	86	102	116	139	194
.24	1.12	27	34	39	42	46	49	52	54	57	59	63	69	78	93	105	128	178
.26	1.19	25	31	35	38	42	44	47	49	52	54	58	63	71	85	96	117	163
.28	1.25	22	28	32	35	38	41	43	45	48	49	53	58	65	78	90	107	152
.30	1.31	21	26	30	32	35	37	40	42	44	45	49	53	61	72	83	100	142
.32	1.37	19	24	27	30	33	35	37	39	40	42	45	50	56	68	76	93	131
.34	1.44	18	22	25	28	30	32	34	36	38	39	42	46	52	63	72	87	123
.36	1.50	16	20	23	26	28	30	32	33	35	37	39	43	49	59	67	81	115
.38	1.57	15	19	22	24	26	28	30	31	33	34	37	40	45	55	62	76	108
.40	1.63	14	18	20	23	24	26	28	29	31	32	35	38	43	52	59	72	101
.42	1.70	13	17	19	20	23	24	26	27	29	30	32	36	40	48	55	67	96
.44	1.77	12	15	18	20	21	23	24	26	27	28	30	33	38	45	52	64	91

- $df_{Err} = 54$
- Sample Size: $df_{hyp} + df_{Err} + 1$
- 6 + 54 + 1 = **61**
- We need **61** participants to reach a power of .80



Method 2: G*Power

G*Power

- Great Power calculator
- Allows you to Calculate sample size (Given power, α, and effect size)
- You can also calculate the power of a study (sample size, α, and effect size)
- …And more!

A-priori vs post-hoc power analysis

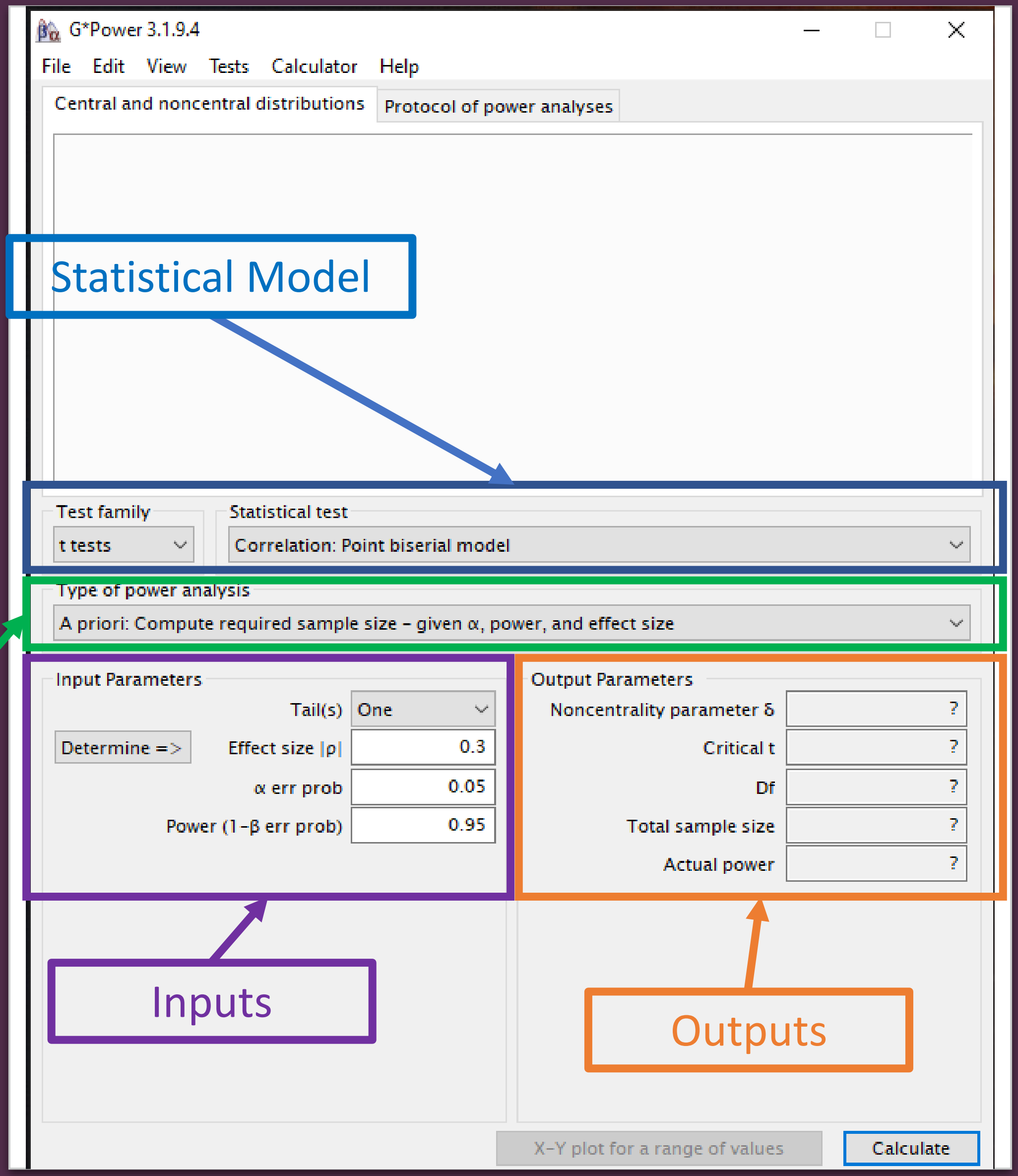
- **A-priori** = When you run the power analysis ***BEFORE*** you run the study to determine the sample size.

- **Post-hoc** = When you run the power analysis ***AFTER*** you run the study to determine how much power the study had.

A-priori is preferred, but sometimes we find ourselves in situations where **the only option we have is a post-hoc analysis**.

The G*Power Calculator

Type of analysis (a-priori or post-hoc… and more!)



An a-priori example (t-test)

- Your *planned* study is a randomized control treatment assessing the mean differences of sexual knowledge scores between participants that took a 12-week sexual education class vs. those in a control group (No class). An independent samples t-test will be used to assess this difference. You want to use an alpha level of .05 and a recent meta-analysis that came out has shown that sexual education classes show an effect size of 0.12. What sample size would be needed to achieve a power level of .80?

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An a-priori example (t-test)

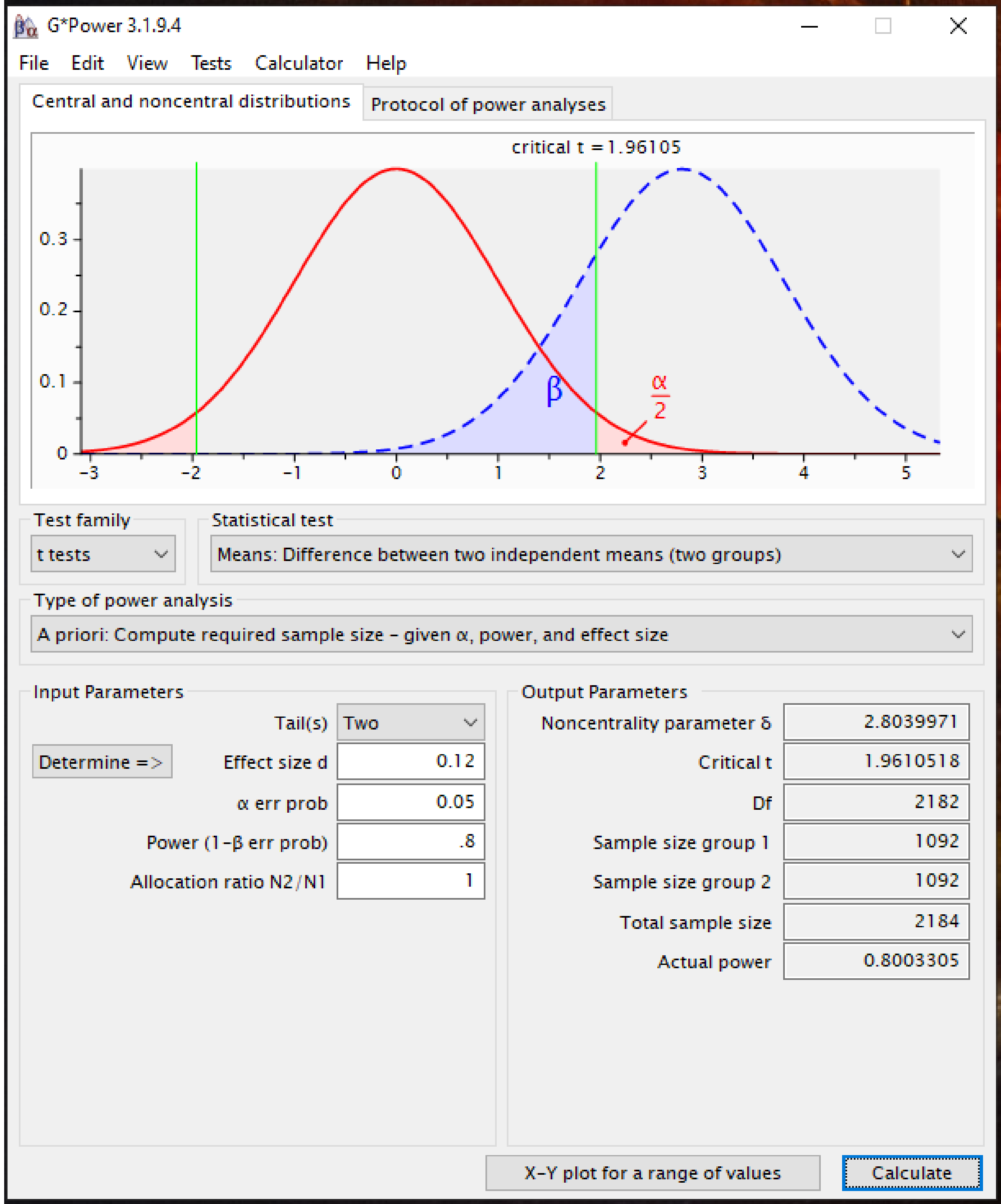
Tails = Two (Because we never indicated a direction of effect)

Effect size = .12

α = .05

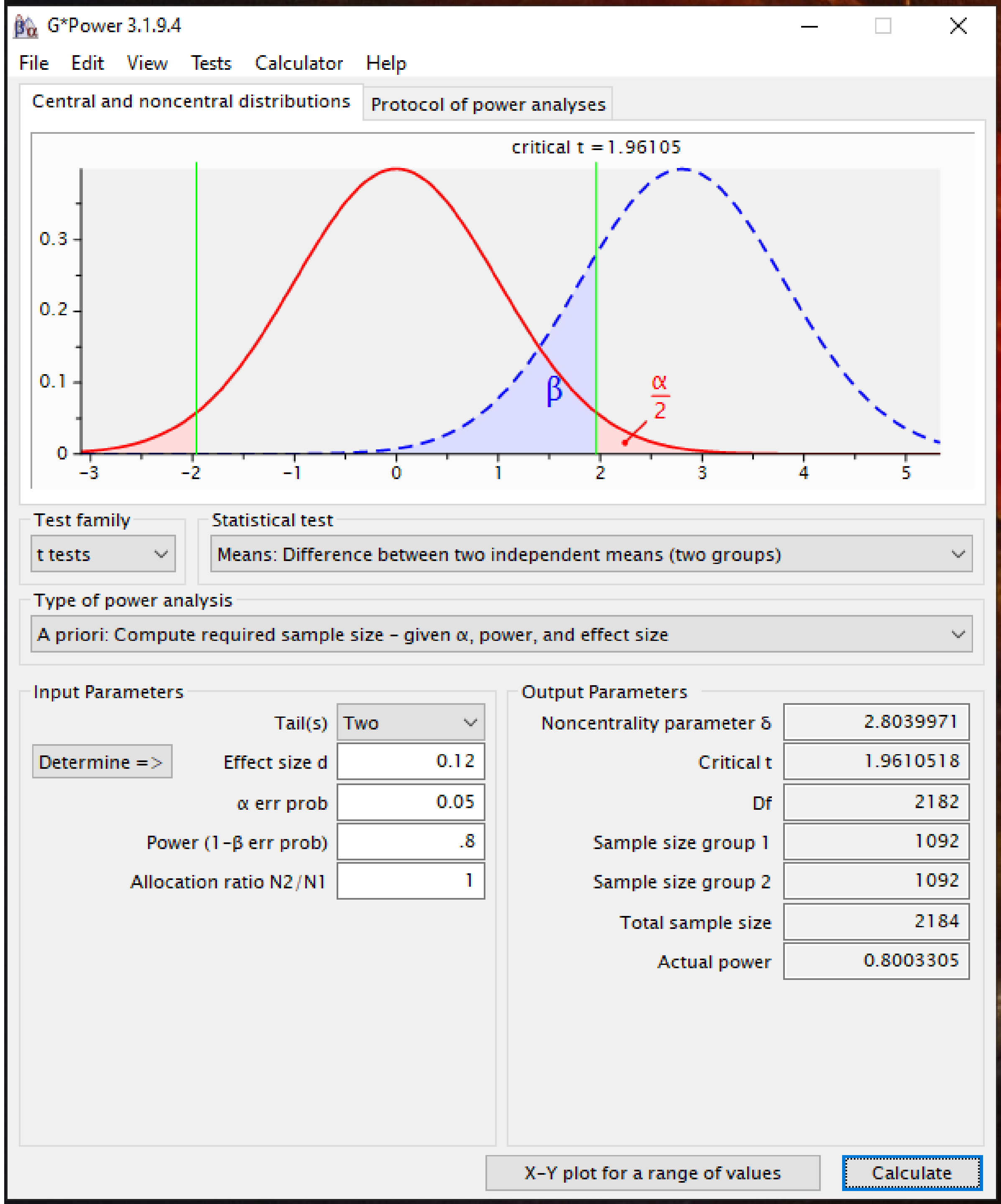
Power = .8

Allocation ratio = 1 (Change this only if you suspect your group sizes will be different)



An a-priori example (t-test)

Total sample size needed = 2184 for a desired power of .80!



Another a-priori example (Omnibus ANOVA)

- You are focused creating study with 3 groups trying to see if different yoga interventions have any effect on eating habits in college students. The plan is to conduct a one-way ANOVA. Generally, the expected effect size for interventions like these on eating habits is 0.15. Using an alpha value of .05, what sample size would be needed to obtain a power of .80?

Another a-priori example (Omnibus ANOVA)

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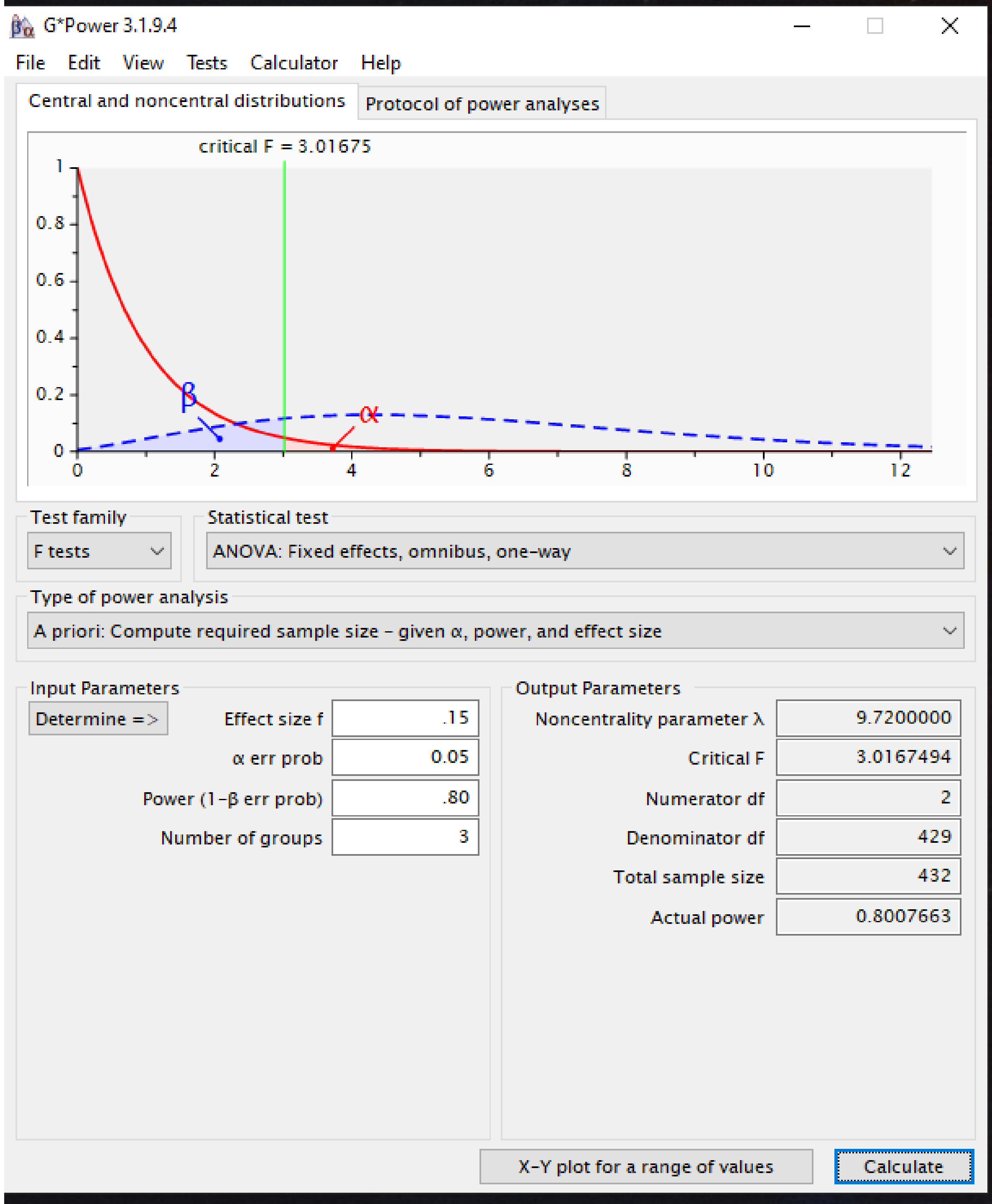
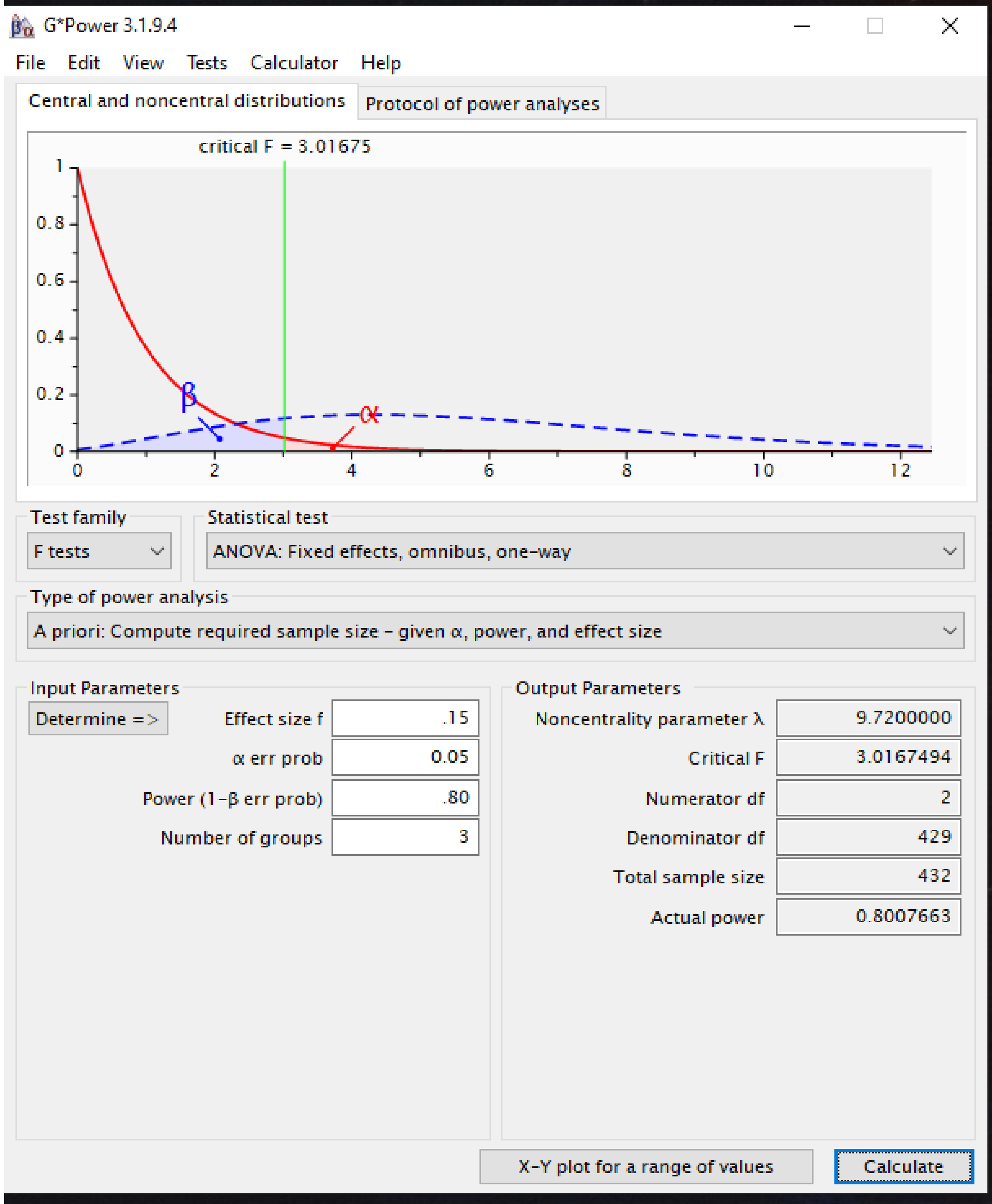
Another a-priori example (Omnibus ANOVA)

- **Effect size** = .15
- α = .05
- **Power** = .80
- **Number of groups** = 3



Another a-priori example (Omnibus ANOVA)

Total sample size needed = 432 for a desired power of .80!



A post-hoc example (t-test)

- You recently ran an experimental study and failed to find significance between the control and treatment group when alpha was set at .01. The completed study yielded an effect size of .25 between the two groups. You used an independent samples t-test. Your sample had 200 participants in each group (400 in total). What was the power of your study?

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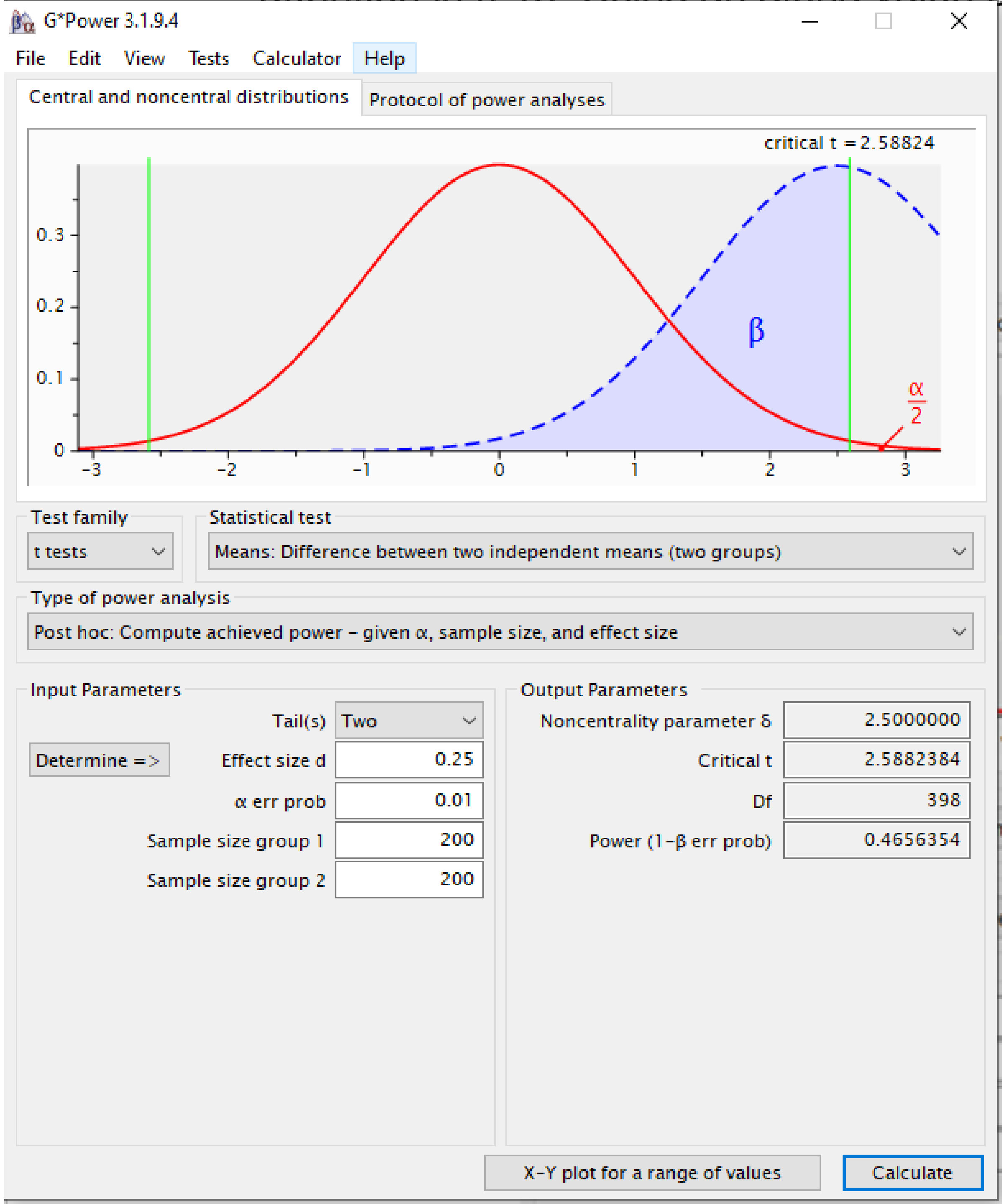
A post-hoc example (t-test)

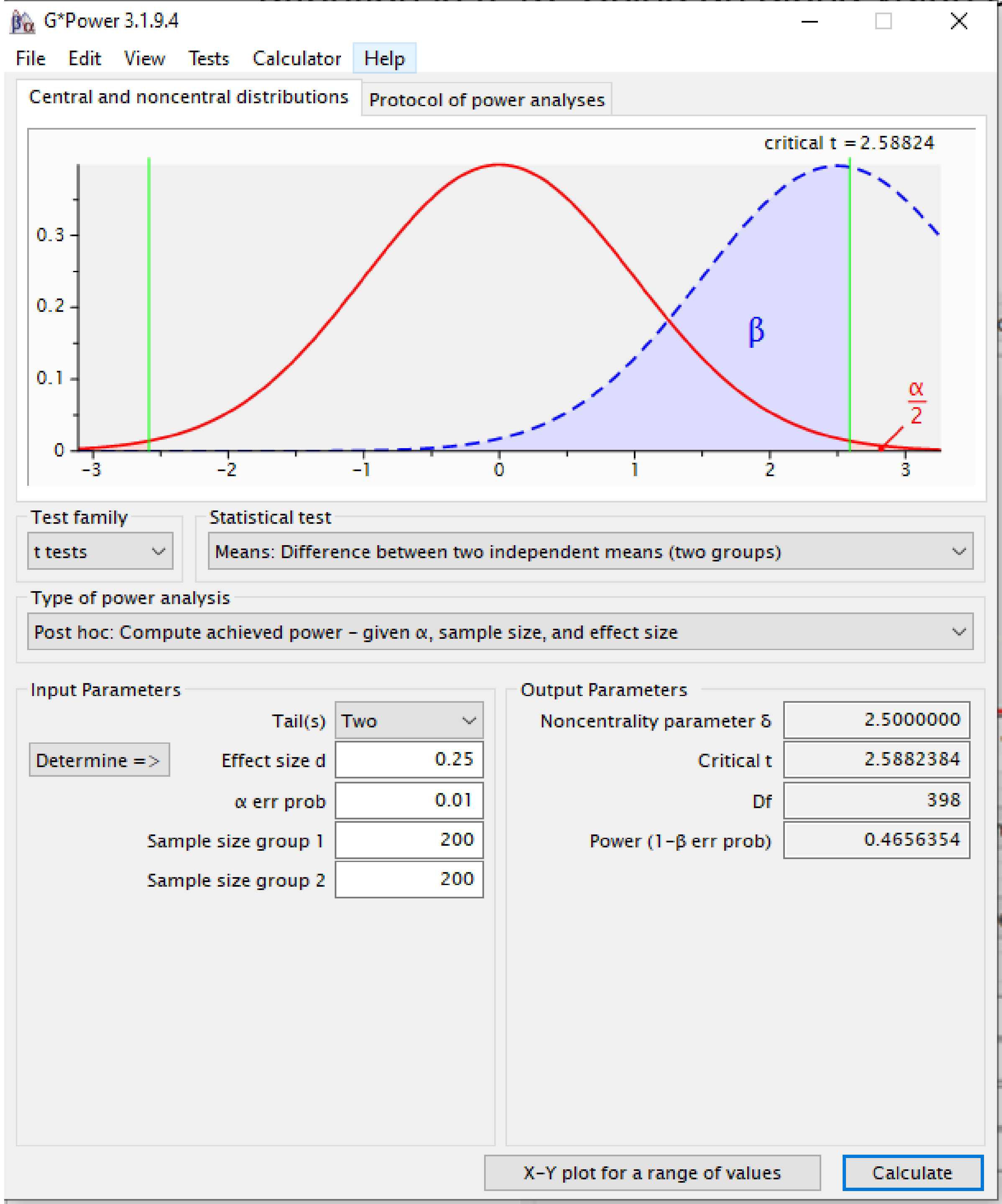
- <u>Tails</u> = Two (Because we never indicated a direction of effect)
- **Effect size** = .25
- α = .01
- **Sample size (1 & 2)** = 200 in each group



A post-hoc example (t-test)

Your study had power of .465, meaning you only had a 46.5% chance of detecting the effect.

This was extremely underpowered!



A post-hoc example (Omnibus ANOVA)

- Your friend conducted a study to compare the impact of 5 different yoga workouts. They recruited a sample of 250 undergraduate students. 50 participants were each assigned to one of the workouts (each participant only did one of the workouts) and they were asked to self-rate their mood after the work out. After your friend collected all of the data, they conducted a one-way ANOVA to compare the mean mood rating across the five types of yoga workouts. At a significance threshold of alpha = .05, the results were non-significant. Previous literature indicates that the effect size for the mean difference across the food groups should be around $f = 0.1$. Was their study sufficiently powered to detect an effect of $f = 0.1$, if it exists, across the four groups?

A post-hoc example (Omnibus ANOVA)

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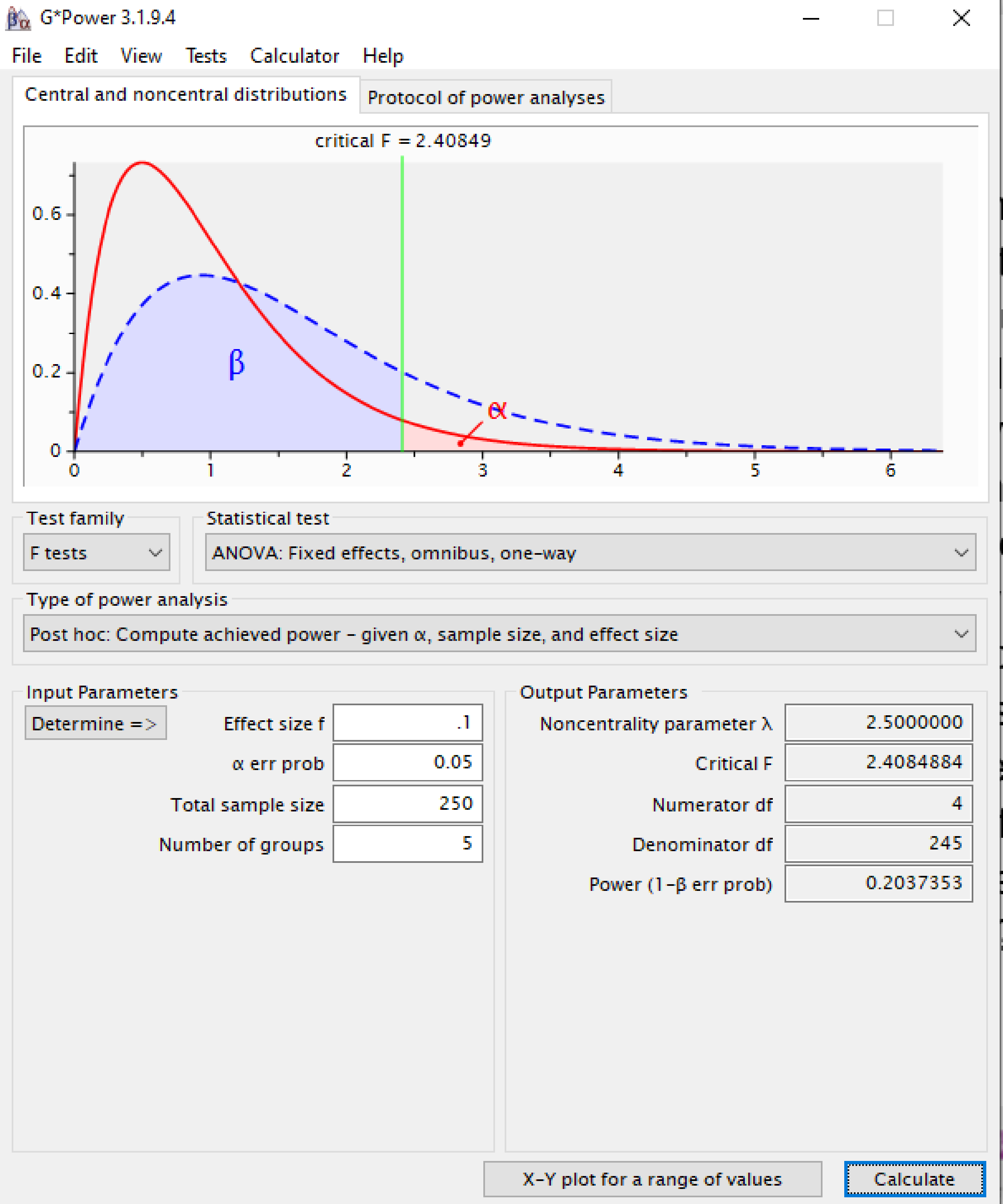
A post-hoc example (Omnibus ANOVA)

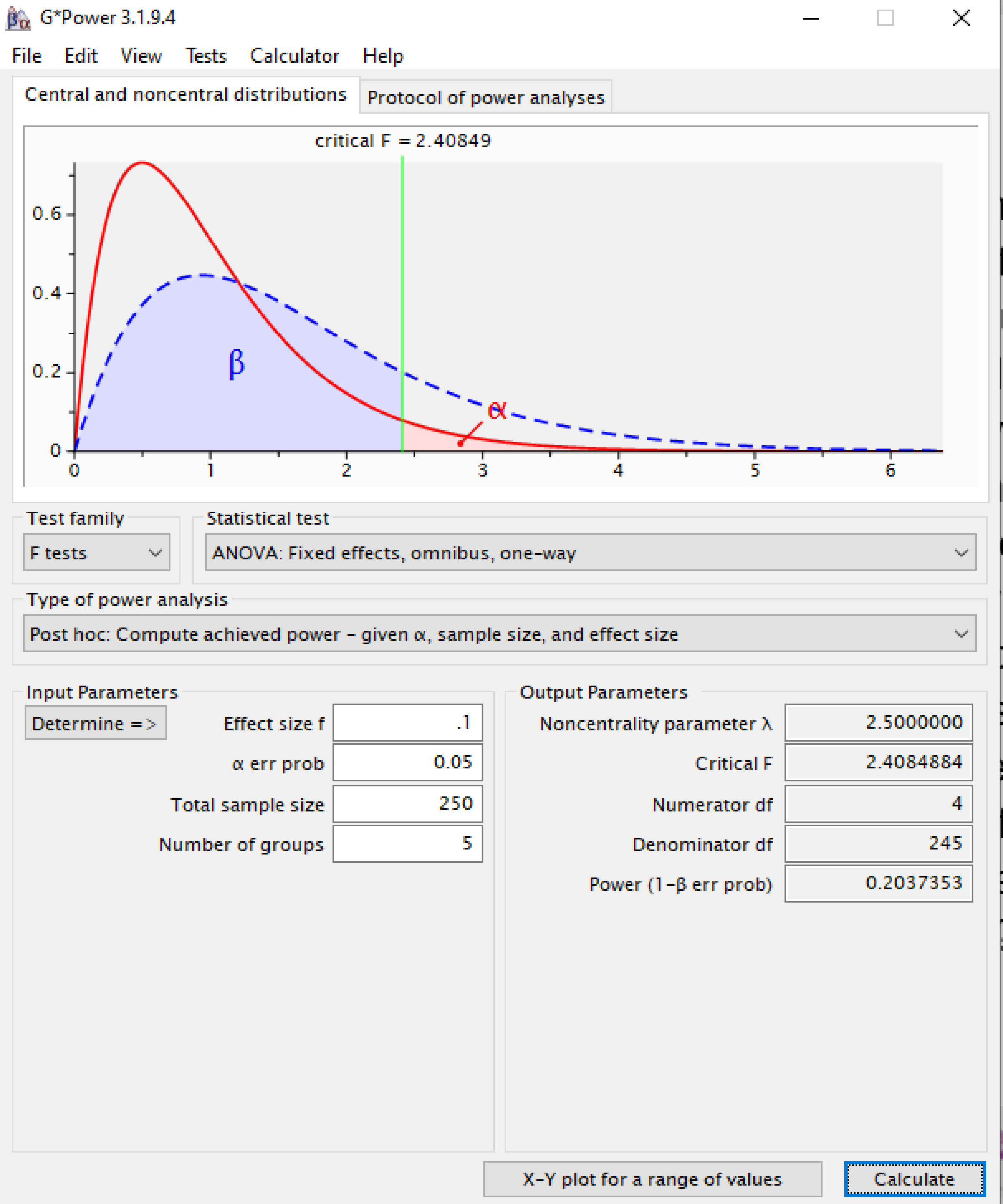
- **Effect size** = .10
- **α** = .05
- **Sample size** = 250
- **Number of groups** = 5



A post-hoc example (Omnibus ANOVA)

Your study had power of .204, meaning you only had a 20.4% chance of detecting the effect.

Again, this was extremely underpowered!



In conclusion

- Power is the probability you will detect the effect (i.e. a power of .70 means you have a 70% chance of detecting the effect)
- Power analyses are essential to any study
- Effect size, alpha value, and sample size drive how much power you have
- You learned two methods to calculating power:
  - Murphy, Myors & Wolach (2014) Appendix E
  - G*Power

- *Now do the assignment on Canvas!*